ISSN 0040-6015, Thermal Engineering, 2013, Vol. 60, No. 8, pp. 559–566. © Pleiades Publishing, Inc., 2013.
Original Russian Text © A.Yu. Kultyshev, A.A. Blagodarev, A.V. Gladkii, D.N. Shanturov, 2013, published in Teploenergetika.

STEAM-TURBINE, GAS-TURBINE, AND COMBINED-CYCLE PLANTS AND THEIR AUXILIARY EQUIPMENT

The Experience of Implementing and Using the Windchill Product Lifecycle Management System at the Energy Machine Building Enterprise

A. Yu. Kultyshev[a, b], A. A. Blagodarev[a], A. V. Gladkii[c], and D. N. Shanturov[a]

[a] *ZAO Ural Turbine Works, ul. Frontovikh Brigad 18, Yekaterinburg, 620017 Russia*
[b] *Ural Federal University, ul. Mira 19, Yekaterinburg, 620002 Russia*
[c] *ZAO EP Audit, pr. Obukhovskoi Oborony 120, lit. I, St. Petersburg, 192012 Russia*

Abstract—The experience of developing, implementing, and adapting the Windchill v.10 product lifecycle management (PLM) system intended for the automation of the control processes by the engineering data for the entire lifecycle of the hardware at the ZAO Ural Turbine Works (UTW) is described.

Keywords: PLM system, design and manufacturing production preparation, design and manufacturing representation of the hardware's structure, steam-turbine installation

DOI: 10.1134/S0040601513080065

n order to optimize planning and control processes by the production of the main and auxiliary equipment of gas-turbine and steam-turbine installations, the Ural Turbine Works (UTW) accepted the decision to form a unique corporative actual database of produced wares [1] as well as to introduce the modern automation methods of control processes by the engineering data and to adapt them to the existing production [2]. The formation of a unique corporative database had become the main target of the project "The Introduction of the Control System by the Engineering Data Based on the Solutions of the RTS Company at the UTW" with the participation of the ZAO EP Audit. To implement the project, the managing committee and the working group were formed in autumn 2011, and the required specifications and the time schedule of the project were developed. To attain the stated target, the following problem should be solved [3]:

(i) to form the infrastructure;

(ii) to optimize the development and design processes;

(iii) to control the hardware compositions;

(iv) to automate the procedures of coordination and confirmation;

(v) to automate the introducing processes of the variations;

(vi) to automate the processes of the manufacturing preparation of the production.

PROBLEM 1. THE FORMATION OF THE INFRASTRUCTURE

To implement any project of the all-factory data control system, large-scale inventory and modernization of the existing infrastructure are required. The actual database, which is accessible only for some of the enterprise services, is useless. The lack of personal computers and the partial covering of the enterprise by the corporative net annul the effect of implementing the data control systems. The IT infrastructure is a foundation of the implementation project.

When realizing the project, the working places of designers and technologists were equipped with modern computers. Each engineering service has a plotter in its disposal now. The corporative net envelopes all divisions of the enterprise involving the shops.

The archive service was also equipped by modern copying equipment, which makes it possible to provide printing, scanning, and binding large documentation volumes.

PROBLEM 2. OPTIMIZATION OF THE DEVELOPMENT AND DESIGN PROCESSES

For the period from the end of 2011 to the beginning of 2012, the optimized processes of the production design and engineering preparation were described at the UTW. All the developed processes were fixed in the corresponding regulating documents. The following processes were enveloped:

the main process of the organization of the production;

the supporting processes:

(i) the coordination of the documentation and the hardware structure in the electronic form;

(ii) registering the problems and introducing the changes;

(iii) the control over the unique libraries of the reference data (RD);

(iv) loading of the previously developed (scanned) documentation into the Windchill system [4].

Each process was described using the source–input–process–output–customer (SIPOC) analysis. This procedure controls the sequence of the works, the actualized roles, the problems performed in the frameworks of each work, and the information suppliers and consumers. Such a description gives exhaustive information on the required system superstructures and, in addition, the normative basis for the implementation of subsequent problems and organizational changes is formed. The thus described process is imposed on the existing organizational structure of the enterprise, which makes it possible to reveal the deficient or excessive organization units (the departments, the bureaus, the divisions, the positions, etc.).

Further, the organizational changes were performed, which were necessary to implement the designed business processes. One such change was the formation of a new department, namely, the Reference Documentation Center (RDC). The idea of the center is that all control over the documentation at the enterprise is passes through one hand, namely, the firm copies, the regulating documentation (both in paper and in electronic form), limiting lists, etc. This division involved a multitude of functions, which were performed earlier by various technical services:

(i) storing, accounting, replicating, and controlling the exemplars of the technical documentation;

(ii) introducing the approved changes and controlling the presence of the exemplars taken into account and the removal of the discontinued documents;

(iii) accompanying the reference base of the enterprise;

(iv) performing the norm control to the design, manufacturing, working, and internal rule documentation;

(v) controlling and accounting of the technical documentation in the Windchill;

(vi) holding the reference data of the enterprise in the actual state.

No fewer global variations were performed in the preproduction preparation (PPP) unit: the production engineering center, or the division, which stands above the entire PPP unit (mechanics, welder operators, and metallurgists) and determines the strategy direction on the localization degree of production of wares, as well as shortens the gap between the units of the design production preparation (DPP), the PPP, and the production.

For the same period, all necessary instructions for the enterprise collaborators, for example, the designer engineer, the technologist engineer, etc., as well as on various directions of activities, were developed in the Windchill system:

(i) on the formation of the material specification and the route accompanying card (RAC);

(ii) on working out the tasks;

(iii) on the coordination of the claims for the formation of the library elements of the normalized equipment;

(iv) on the formation of the libraries of the standard and other wares and their use;

(v) on the formation of the packages and claims for printing the documentation;

(vi) on the joint design in the Creo computer-aided design (CAD) system and the Windchill system [5];

(vii) on the formation and edition of specifications, etc.

It should be noted that all instructions were developed and corrected according to the actual and newly developed regulating documents (the enterprise standards (STP), the organization standards (STO), orders, etc.) [6].

PROBLEM 3. CONTROL OVER THE COMPOSITION OF WARES

The data structuring for their subsequent use in planning systems is based on the control over the hardware composition rather than the electronic archive. Starting from the project beginning, such notion as the hardware structure, or the hierarchy tree, which reflects the wares composition from the "head specification to the last bolt" had become common at the enterprise. The hardware structure can contain data larger than the specification by an order of magnitude. Its construction is the first important step to the representation of the data suitable for the automated processing.

The investigation and the adoption of the instruments and the functioning of the Windchill system by the members of the working group of the UTW had become one of the key implementing events. After this, the mass learning of the collaborators of the Special Design Turbine Manufacture Bureau (SDTMB), which passed with the work being continued at actual current problems, and the collaborators that participated in the trial operation of the system and developed the structure of the hardware "Steam-Turbine Installation T-63/76-8.8. The Volume of the Plant Delivery" by the current delivery order to the Izhevsk TETs-1 (heat electropower station). The upper level of this structure is presented in Fig. 1.

The hardware structure as well as its filling with the scanned documentation was performed by the SDTMB specialists manually based on the previously

MT-268700	T-63/76-8.8 steam-turbine installation. Plant delivery volume	
MT-238503-05	PSG-1300 network heater with equipment	1
MT-238503-07	PSG-1300 network heater with equipment	1
MT-268701-01	K-6000-XII condenser with equipment	1
MT-268702	T-63/76-8.8 steam turbine with equipment	1
MT-268944	T-63/76-8.8 EChSRiZ	1

Fig. 1. Upper structure level of the hardware "T-63/76-8.8 Steam-Turbine Installation. Plant Delivery Volume" in the Windchill system.

developed specifications. As for the new design, the use of progressive CAD (Creo Parametric) made it possible:

(i) to obtain the hardware structures of the Windchill system automatically with the offload of the assemblies formed in Creo Parametric (the example of the structure with the coupled CAD documents of the Windchill system is presented in Fig. 2) [7];

(ii) to obtain the three-dimensional models and the associative drafts with the attributive data offloaded into the objects of the Windchill system (Fig. 3);

(iii) to generate the library elements from Tekhnonorma/IntraCAD with the attributive information for offloading into the libraries of the Windchill system.

The hardware structure as a whole is constructed from elements, namely, its parts that symbolize the details, the assemblies, the standard and other wares, and the materials. The purchased elements (the standard and other wares as well as the materials and other library elements) are used in many structures. Therefore, it is especially important to have a unique record, which unambiguously characterizes this element, for elements with wide applicability. Because of the importance of the problem, the formation of all library elements, which are required to construct the structures, was entrusted to the again formed RDC, in which the special bureau of the RD administrators was singled out.

PROBLEM 4. AUTOMATION OF THE COORDINATION AND THE CONFIRMATION CONDITIONS

The transition to the electronic procedures implies the cancellation of the documentation coordination in a paper form (the cancellation of the signatures), and the corresponding regulatory base is required for the solution of this question. In March 2012, the order of the General Director of the UTW equalized the personalization of the collaborator by means of the login and the parole to the personalization by a personal signature on a paper document. Already starting from April 2012, according to the order on implementing the Windchill system into the pilot operation, the SDTMB collaborators performed the storage, the variation, and the coordination with all other plant

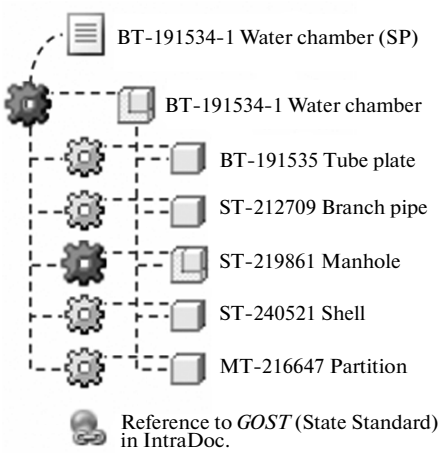


Fig. 2. Example of the structure with the associated CAD documents.

services (including the normal inspection bureau) of the entire volume of the again developed documentation in the Windchill system. The plot of increasing the volume of the coordinated documents through the Windchill system is shown in Fig. 4.

In addition to the coordination procedures of the design and production documentation, the processes of scanning the archive documentation, the formation of the base of library objects (the materials and the standard and purchase wares), the order of documentation printing, and so on, were implemented.

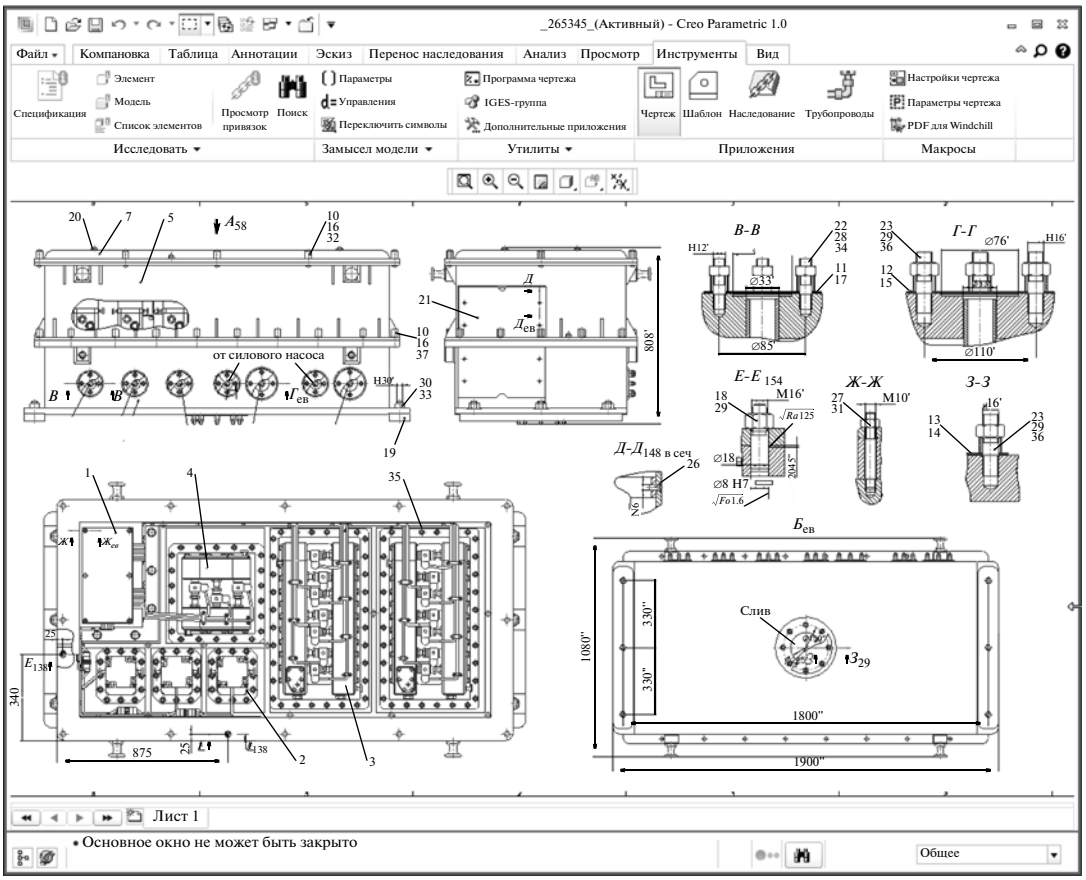
According to the same order on putting into pilot operation, the claims are submitted and fulfilled in the Windchill system:

(i) for the documentation scanning from paper archives;

(ii) for printing of the design and production documentation according to the organized delivery by the needs of archives of industrial divisions allowing for the fabrication routes of the equipment details and units.

Starting from the beginning of the pilot operation, the scaled filling of the electronic archive of the documentation occurs, which is attracted to all the design structures of the wares developed to the current instant. These structures can be further borrowed by the details, the units, or entire complexes in the newly developed wares. The plot of an increase in the number of scanned documents is shown in Fig. 5.

The use of the archive makes it possible to increase the access operability and thereby to release the time for the fulfillment of the direct obligations both for the developers of the documentation and for other frequent users (the collaborators of the purchase sector, the collaborators of the production services, engineer chiefs of the department of the external mounting, etc.).


_265345_(Активный) - Creo Parametric 1.0
Файл
Компановка
Таблица
Аннотации
Эскиз
Перенос наследования
Анализ
Просмотр
Инструменты
Вид
Спецификация
Элемент
Модель
Список элементов
Просмотр привязок
Поиск
Параметры
Управления
Переключить символы
Программа чертежа
IGES-группа
Дополнительные приложения
Чертеж
Шаблон
Наследование
Трубопроводы
Настройки чертежа
Параметры чертежа
PDF для Windchill
Исследовать
Замысел модели
Утилиты
Приложения
Макросы
от силового насоса
Слив
1800"
1900"
1080"
340
Лист 1
• Основное окно не может быть закрыто
Общее

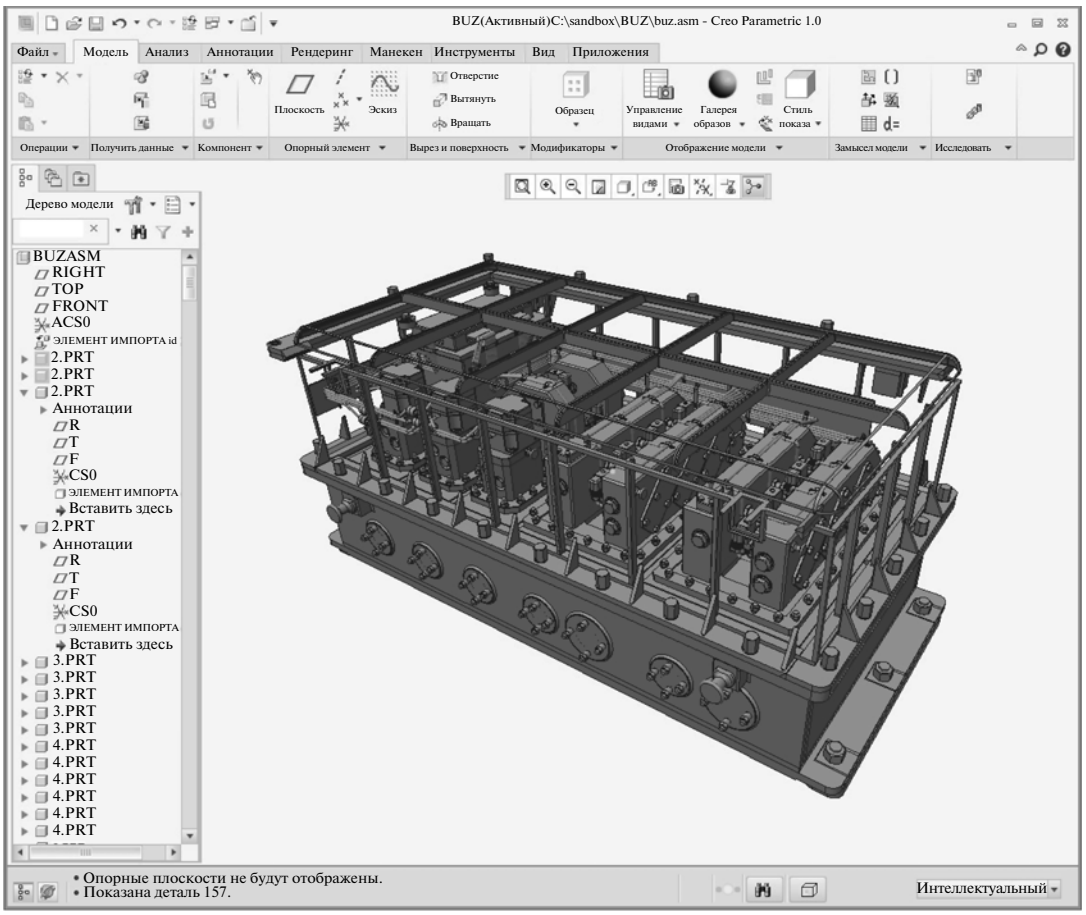

BUZ(Активный)C:\sandbox\BUZ\buz.asm - Creo Parametric 1.0
Файл
Модель
Анализ
Аннотации
Рендеринг
Манекен
Инструменты
Вид
Приложения
Дерево модели
BUZASM
RIGHT
TOP
FRONT
ACS0
2.PRT
3.PRT
4.PRT
Аннотации
Вставить здесь
• Опорные плоскости не будут отображены.
• Показана деталь 157.
Интеллектуальный

Fig. 3. Example of the associative drawing and 3D hardware model.

PROBLEM 5. AUTOMATION OF THE PROCESSES OF INTRODUCING THE CHANGES

It should be noted that the measurement process was substantially improved. After this, it was constructed based on the ISO 9001 standard, which somewhat changed the approach—initially, the comprehensive analysis, the confirmation, and planning are fulfilled; after this, the system allows only one to introduce the changes. The Windchill system records all processes, starting from the problems and deviations from the design documentation, submitted by the collaborators of any plant divisions, to their solution by the developers. The collaborators are appointed among the designers, technologists, and dispatchers, who fulfill the role of administrators of the changes. They determine the routes of their coordination (short or long), develop the implementation plans, and monitor the passage of the changes at various stages of their performance.

The monitoring system shows the number of unresolved problems, the requests at the coordination stage, and messages on the changes in the implement stage in any instant.

PROBLEM 6. OPTIMIZATION OF THE PRODUCTION PREPARATION PROCESSES

The following problems are resolved in the plant production services with a certain time shift from the measures performed according to the DPP to organize the systematized control by the production process (PP) to provide the optimal planning and control production processes:

(i) the optimization of the existing PPP processes;

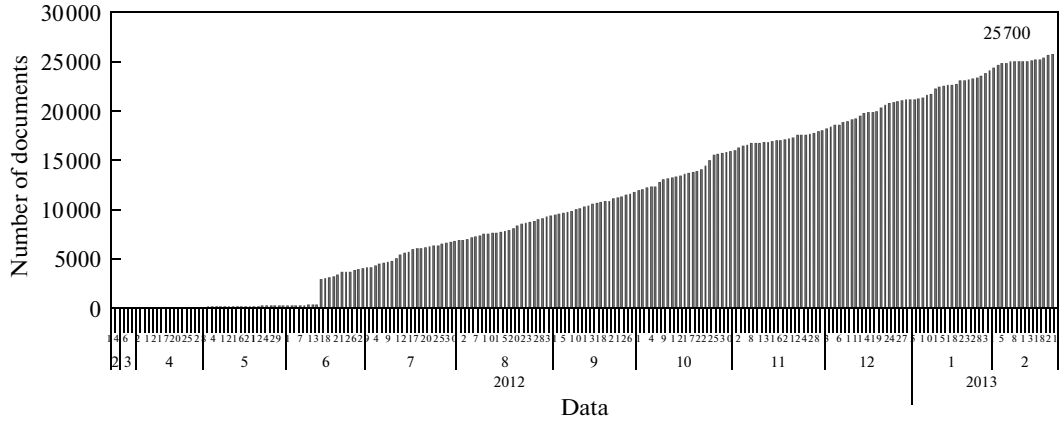


Fig. 4. Plot of the accumulation of the documentation volume coordinated using the Windchill system.

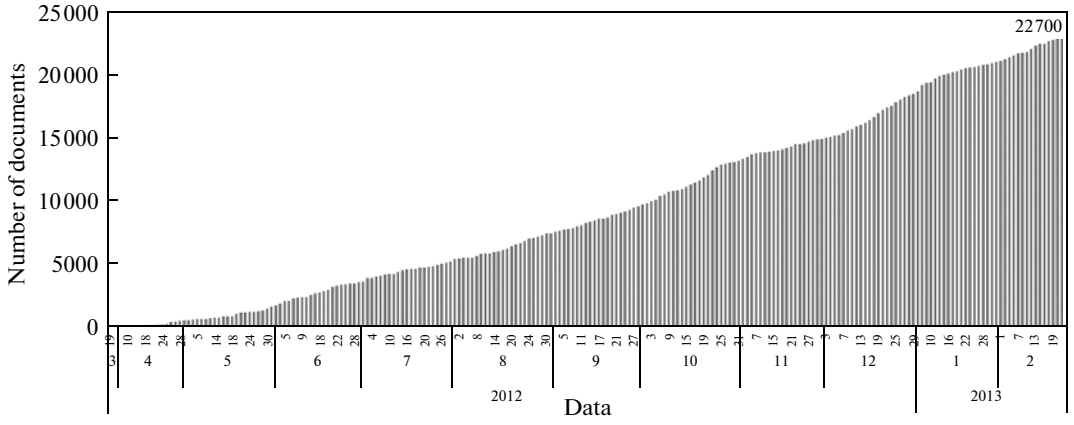


Fig. 5. Plot of raising the number of scanned documents.

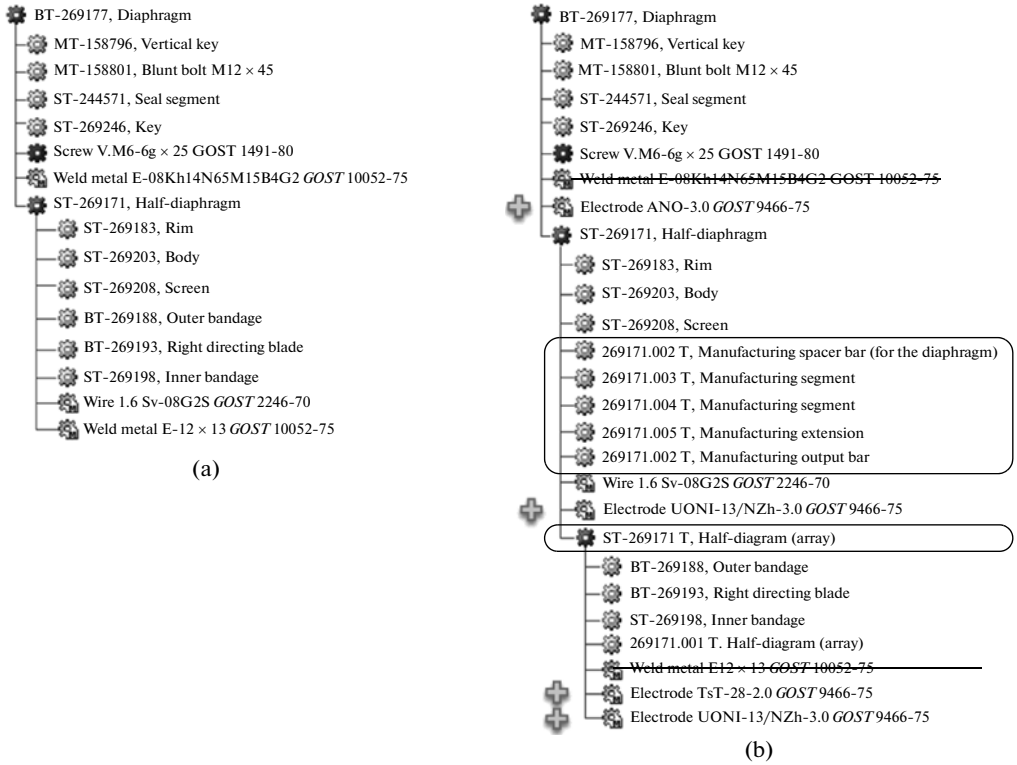


Fig. 6. Difference of hardware structures in (a) design and (b) production representation by the example of the diaphragm of the 17th step of the T-63/76-8.8 turbine.

(ii) the formation of the production hardware structures based on the design ones;

(iii) the preparation of the data for the preliminary production and purchase planning (the provision of the possibility to assign the preliminary material rationing, the fabrication route at the early PPP stages, as well as the determination of "critical" details and units due to the information on the ware production sequence);

(iv) the PPP performance (the PP development by means of detailing the route stages and determining the PPP sequence by the special equipment; the design of the special production equipment);

(v) the formation of the RD catalogs as applied to the PPP and their control;

(vi) the formation of the output electronic data and paper-carrier documentation on the PPP for production needs (along with the RDC).

The pilot operation of the Windchill system in the part of the PPP, during which the above-listed problems in the carrying order for the production and delivery of the T-63/76-8.8 steam-turbine installation were solved, was performed simultaneously with the solution of these problems in the plant production services.

Implementing the production hardware structure was the first serious know-how suggested by the EP Audit Company. The problem of its construction was solved in the course of the pilot operation of the PPP unit. The distinctions of the design structure from the production one are presented in Fig. 6 by the example of the diaphragm of the 17th step of the T-63/76-8.8 steam turbine.

Compared with the design solution, the production hardware structure is represented as follows:

(i) it reflects the hardware production and assembly process, namely, it contains the units and subassemblies, which physically exist in the production (they can be distributed over various shops, or be collected; it can be planned);

(ii) it does not contain the sites not touching the design (the tests and dismounting works);

(iii) it contains the units not existing in the production (the design organization assemblies and complete sets are distributed over the actual physical assemblies);

(iv) it reflects the actual production hardware composition allowing for the requirements to tuning and mounting;

(v) it contains the materials and manufacturing details necessary to produce the wares (the welded metal is replaced by the actual electrode grade with the actual application rate).

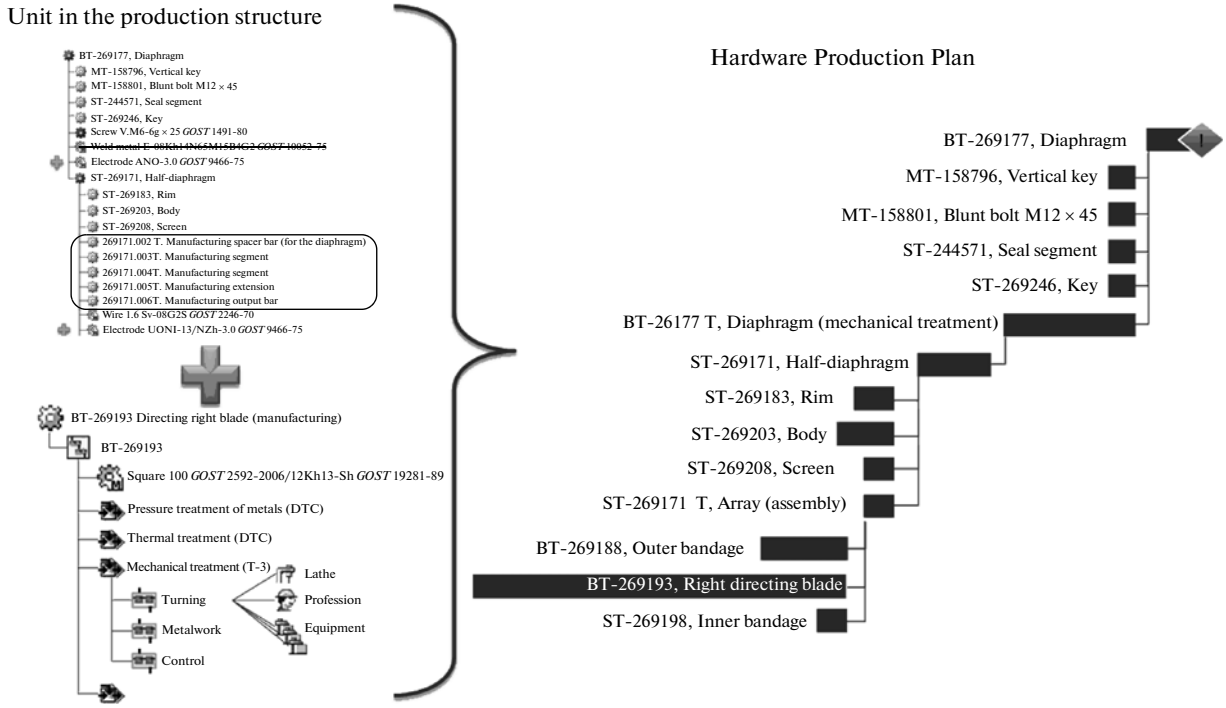


Fig. 7. Example of the production plan.

The second serious variation in the PPP is implementing the end-to-end PPs, which combine previously discrete flowcharts of the mechanical, metallurgical, and welding PPs in one process of the article production. The billet of the rolled metal is supplied to the PP input, and the ready article is obtained at its output.

The end-to-end PPP consists of the sequence of process stages, which are opened to the chain of operations, each of which requires the necessary equipment, the profession, and the facilities, and contains the information necessary as a whole in order to fulfill the operation (the text, the drafts, and the time allowance). The special facilities required to perform the operation can also have its own production process, and so on, in this case. Using this data model, we can obtain all resources necessary to produce the ware, and combining it with the production hardware structure, we can construct its production plan and, consequently, to attain the stated goal (Fig. 7 shows an example of the production plan).

CONCLUSIONS

Currently, all the DPP and PPP stages are performed using the Windchill system, while the production shop has operated with the system documentation in full starting from January 1, 2013; which makes it possible to shorten the output time of the turbines and the auxiliary equipment due to:

(i) the complete digital hardware description and the organized access to the actual information on the ware;

(ii) the transformation of the current processes of the design preproduction preparation (DPPP) into a new, more efficient process based on modern information technologies;

(iii) the streamlined joint operation of the divisions involved into the DPPP;

(iv) the production prepreparation using unique catalogs of the production resources and the repeated information application;

(v) the work performance in one program medium with the common starting data, i.e., using the single data field at the plant.

The data on more than 100000 details and assembly units is contained in the Windchill system at the UTW, which allows us to speak about the sufficient system fullness and success in its use already on finishing the first year of implementing and adapting to specialized high-tech production.

REFERENCES

1. I. V. Tselikov, Operative Production Control: Presentation, 2011, http://www.mescenter.ru/mesaconf/presentations/mesa2011_tselikov.pdf.
2. V.I. Brezgin, Yu. M. Brodov, V. V. Kortenko, and A. A. Chubarov, “Application of the CALS Concept by the Example of the District-Heating Steam-turbine

Installation" Tyazheloe mashinostroenie, Moscow, 2002) [in Russian].

3. E. Goretkina, "How to bypass the traps on the way to PLM, *PC Week*, No. 11, 2006; http://www.nslabs.ru / articles/?child_id=2.
4. Yu. P. Zyryanov, V. Yu. Kolobov, and V. V. Turova, "Experience of introducing modern PDM-systems and CADs at the ZAO 'Ural Turbine Plant,'" CAD/CAM/CAE Observer, No. 5 (2008).
5. A. A. Ivanovskii, F. A. Shamrai, A. V. Bulanov, and A. A. Blagodarev, "CAD as the key to the development of the mechanical engineering enterprise," PC Week/RE, No. 22, 580 (2007) (see http://www.pcweek.ru/ themes/detail.php?ID=82694).
6. K. V. Tatarenkov, "Production modernization along with ZAO 'EP-Audit'" ("Za Pobedu" (For Winning), the newspaper of OAO Uraltransmash, 2012, part 3, http://ep-audit.spb.ru/ru/news/show/90.
7. V. V. Kortenko, A. E. Valamin, D. N. Shanturov, E. V. Sokolov, S. V. Toibich, and A. N. Glushchenko, Experience Gained at ZAO Ural Turbine Works with the Use of Computer-Aided Design Systems, *Thermal Engineering,* 55 (8), 684 (2008).

Translated by N. Korovin